PRODUCTION OF LIQUID CRYSTAL DISPLAY DEVICE

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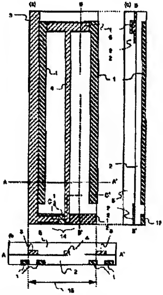
Abstract of **JP7261181**

PURPOSE:To obtain a liquid crystal display device which is increased in tolerance for contamination of liquid crystals and orientation process and is free from unequal display by combining a transverse electric field system and a polymer for which a low heating temp. after applying is enough and is soluble in a solvent with active matrix elements such as thin-film transistor element.
CONSTITUTION:The matrix elements are formed by having scanning electrodes 12, common electrodes 1, signal electrodes 3 intersecting with the scanning electrodes 12, active elements and pixel electrodes 4 on one substrate of a pair of substrates constituting a cell and arranging the pixel electrodes 4 and the common electrodes 1 so as to impress electric fields parallel with the substrate planes mainly on the liquid crystals. A soln. of a polymer soluble in the solvent is applied on such substrates. The solvent in the soln. of the polymer is then removed to impart liquid crystal orientability to the surfaces of the polymer. The cell is assembled by disposing a pair of the substrates having the liquid crystal molecule orientability on the surfaces via the sealing part formed in the peripheral parts of the substrates in such a manner that the surfaces having the liquid crystal molecule orientability face each other.



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(54) [Title of the Invention] MANUFACTURING METHOD OF LIQUID CRYSTAL DISPLAY DEVICE

(57) [Abstract]

[Object]

To obtain a manufacturing method of a liquid crystal display device which has high image quality and high tolerance to contamination of liquid crystal or an alignment process without display unevenness.

[Structure]

An alignment film of an active matrix element having an electrode structure to which a horizontal electric field is applied is formed at a low temperature using a polymer which is dissolved in a solvent, whereby a liquid crystal display device with a little display unevenness is obtained.

[Scope of Claim]

[Claim 1]

A manufacturing method of a liquid crystal display device characterized by including the following steps.

(1) A step of providing a scan electrode, a common electrode, a signal electrode which intersects with the scan electrode, an active element, and a pixel electrode over one of a pair of substrates forming a cell, and forming a matrix element in which the pixel electrode and the common electrode are arranged so as to mainly apply an electrical field which is parallel to a surface of the substrate to a liquid crystal.

(2) A step of applying a solution of a polymer which is soluble in a solvent over the substrate.

(3) A step of removing the solvent in the solution of the polymer.

(4) A step of imparting ability of liquid crystal molecule alignment to a surface of the polymer.

(5) A step of assembling a cell in such a manner that surfaces of a pair of substrates, which have ability of liquid crystal molecule alignment, face each other, with a spacer and a sealing portion formed at peripheral portions of the substrates between the pair of substrates the surfaces of which have ability of liquid crystal molecule alignment.

(6) A step of forming a liquid crystal cell by injecting a liquid crystal composition into the cell and sealing the cell.

(7) A step of connecting a driver circuit and a polarizing means to the liquid crystal cell and modularizing the liquid crystal cell.

[Claim 2]

The manufacturing method of a liquid crystal display device described in claim 1, characterized in that the active element is a thin film transistor element.

[Claim 3]

The manufacturing method of a liquid crystal display device described in claim 1, characterized in that the polymer soluble in a solvent is polyimide.

[Claim 4]

The manufacturing method of a liquid crystal display device described in claim 1, characterized in that the polymer soluble in a solvent is polyamide.

[Claim 5]

The manufacturing method of a liquid crystal display device described in claim 1, characterized in that the substrate of the pair of substrates, which faces the substrate having the matrix element, is subjected to the (2) to (4) steps.

[Claim 6]

The manufacturing method of a liquid crystal display device described in claim 5, characterized in that a color filter is formed over the substrate which faces the substrate having the matrix element, and color-developing ability of a plurality of colors is imparted to the liquid crystal cell.

[Claim 7]

The manufacturing method of a liquid crystal display device described in claim 1, characterized in that the substrate having the matrix element, of the pair of substrates, is subjected to the (2) to (4) steps.

[Claim 8]

The manufacturing method of a liquid crystal display device described in claim 7, characterized in that a color filter is formed over the substrate having the matrix element and color-developing ability of a plurality of colors is imparted to the liquid crystal cell.

[Claim 9]

The manufacturing method of a liquid crystal display device described in claim 6 or 8, characterized by including the following steps.

(1) A step of forming a film having a plurality of color developing layers.

(2) A step of forming a color filter by irradiation with a light pattern including a plurality of colors.

[Claim 10] The manufacturing method of a liquid crystal display device described in claim 9, characterized in that a light irradiation step is performed once.

[Claim 11]

The manufacturing method of a liquid crystal display device described in claim 9 or 10, characterized in that after forming a color filter by irradiation of a film including the color developing layer which is interposed between a pair of polymer protective films with a light pattern, the film is attached over one of the substrates.

[Claim 12]

The manufacturing method of a liquid crystal display device described in claim 6 or 8, characterized in that light-shielding layers which block boundary portions of a plurality of color filters are formed over at least one of the pair of substrates at the time of assembling the liquid crystal cell.

[Claim 13]

The manufacturing method of a liquid crystal display device described in claim 12, characterized in that the light-shielding film is formed over the substrate having the matrix element, and the plurality of color filters is formed over the substrate which faces to the matrix element.

[Claim 14]

The manufacturing method of a liquid crystal display device described in Means 12, characterized in that the light-shielding layer and the plurality of color filters are formed over the substrate having the matrix element.

[Detailed Description of the Invention]

[Industrial Application Field]

[0001]

The present invention relates to a manufacturing method of an active matrix liquid crystal display device which has high image quality without display unevenness.

[0002]

[Prior Art]

In a conventional active matrix liquid crystal display device, transparent electrodes has been used which are formed on an interface of two substrates and face each other as electrodes which drive a liquid crystal layer. This is because a display mode typified by a twisted nematic display mode (hereinafter referred to as a vertical electric field mode) is employed in which operation is performed in such a manner that a direction of an electric filed applied to a liquid crystal is made to be almost perpendicular to the interface of the substrates. On the other hand, a mode using a pair of comb-shaped electrodes, in which the direction of the electric field applied to a liquid

crystal is made to be almost parallel to the interface of the substrates (hereinafter referred to as a horizontal electric field mode) is disclosed in Japanese Examined Patent Application Publication No. S63-21907, for example; however, a display device using the mode has not been used in practice.

[0003]

[Problems to be Solved by the Invention]

In the conventional active matrix liquid crystal display device using a vertical electric field mode, many problems to be described below are caused due to use of a vertical electric field mode, and as a result of this, it has been difficult to obtain a liquid crystal display device which has high image quality without display unevenness.

[0004] (1) Precise control of the interface

When a vertical electric field mode and a minute active matrix element such as a thin film transistor are combined with each other, slight change in interface states causes display unevenness. For example, when a state of a surface of an alignment film is changed, an angle (a tilt angle) between a liquid crystal molecule major axis and the interface is also changed, which leads to change in response of a liquid crystal with respect to application of voltage and change in brightness.

[0005]

The surface state of the alignment film slightly depends on process conditions for forming the alignment film, and precise control of the process conditions has been required. For example, in the case of a polyimide alignment film, a micromolecular film having a dense and uniform surface state is formed in such a manner that, after a low molecular polyimide precursor solution is applied over a substrate, heating is performed, whereby a solvent is dried and a polymerization reaction is promoted. In particular, a heating temperature for promoting a polymerization reaction is, for example, greater than or equal to 200 °C, which is very high. When this high temperature heating condition is changed at this time, the tilt angle is deviated from a designed value, which causes unevenness. The tilt angle depends not only on a heat treatment temperature but also on rubbing conditions. Although the tilt angle tends to become small when rubbing strength is high in general, a degree of the change also depends on a material used for an alignment film, surface contamination of the alignment film due to rubbing, or the like. The tilt angle should not be too large or too small for the following reasons. For example, when the tilt

angle is smaller than the designed value, an alignment defective domain is generated in a portion where a step is generated due to existence of a wiring of an end portion of a pixel, or the like, whereby contrast ratio is drastically reduced. On the other hand, when the tilt angle is larger than the designed value, it is difficult to keep uniformity of the tilt angle, which causes luminance unevenness. At present, in order to obtain a uniform tilt angle of about 4 degrees in terms of mass productivity, a material to be used is selected severely, and on that basis, a heating process, a rubbing process, and the like is severely controlled; however, display unevenness is not removed entirely.

[0006] (2) Keeping of high purity of liquid crystal

Another characteristic which should be taken into consideration when a vertical electric field mode and a minute active matrix element such as a thin film transistor are combined with each other is purity of a material of a liquid crystal composition, and it is essential to keep an extremely high value of greater than or equal to 10^{13} $\Omega{\cdot}$cm. This is required by a drive principle that charges which are supplied to a pixel and stored in displaying information have to be held until at least the subsequent information signal is supplied. In general, a degree of how much the charges are stored in this period (referred to as one frame period) is defined by a proportion of luminance to be kept in one frame period, and is represented as a voltage holding ratio. This voltage holding ratio is extremely sensitive to purity of a liquid crystal; therefore, at present, a compound contained in a material of a liquid crystal composition is limited to a mere part of a fluorine-based compound group. Further, limitation on a material of an alignment film is large. That is, when purity of a material itself of an alignment film which is directly in contact with a liquid crystal is low, after formation of a cell, the material of the liquid crystal composition is contaminated gradually, the voltage holding ratio is extremely lowered, a lowering degree thereof is distributed depending on places, and thus, uniform display cannot be obtained. At present, the maximum attention is paid to contamination of a liquid crystal by cleaning of equipment to be used, or the like; however, the voltage holding ratio is not 100 % and display unevenness is not removed entirely.

[0007] (3) Afterimage phenomenon

Although a mechanism is unknown, a so-called afterimage phenomenon, in which when a still image which is fixed is displayed and then switched to another image, the previous image remains, also strongly depends on materials of both an alignment film and liquid crystal. Since the

mechanism is unclear, the design of the materials is extremely difficult.

[0008]

As described above, it is the most difficult task to meet many required specifications such as precise control of the interface (maintenance of a predetermined tilt angle), keeping of high purity of a liquid crystal, and suppression of an afterimage phenomenon at the same time, and at present, the conventional active matrix liquid crystal display device using a vertical electric field mode is manufactured forcibly in a number of steps under process conditions with an extremely narrow range. For example, in a heating step of an alignment film, treatment is performed at an extremely high temperature of greater than or equal to 200 °C. In this manner, it is essential to set severe process conditions; therefore, the range of choosing other materials included in the liquid crystal cell is narrowed, which further lowers tolerance of the manufacturing conditions and further causes display unevenness easily.

[0009]

The present invention provides a means for solving these problems and the object thereof is to provide a manufacturing method of an active matrix liquid crystal display device which has high image quality without display unevenness in such a manner that an active matrix element, a horizontal electric field mode, and an alignment film formed using a polymer soluble in a solvent, on which treatment can be performed in a process at a lower temperature, are combined with each other.

[0010]

[Means for solving the problems]

In order to solve the problems and accomplish the object, in the present invention, the following means are used.

[0011][Means 1]

A manufacturing method of a liquid crystal display device characterized by including the following steps.

[0012]

(1) A step of providing a scan electrode, a common electrode, a signal electrode which intersects with the scan electrode, an active element, and a pixel electrode for one of a pair of substrates forming a cell, and forming a matrix element in which the pixel electrode and the common electrode are arranged so as to mainly apply an electrical field which is parallel to a surface of the

substrate to a liquid crystal.

[0013]

(2) A step of applying a solution of a polymer which is soluble in a solvent over the substrate.

[0014]

(3) A step of removing the solvent in the solution of the polymer.

[0015]

(4) A step of imparting ability of liquid crystal molecule alignment to a surface of the polymer.

[0016]

(5) A step of assembling a cell in such a manner that surfaces of a pair of substrates, which have ability of liquid crystal molecule alignment, face each other with a spacer and a sealing portion formed at peripheral portions of the substrates interposed between the pair of substrates the surfaces of which have ability of liquid crystal molecule alignment.

[0017]

(6) A step of forming a liquid crystal cell by injecting a liquid crystal composition into the cell and sealing the cell.

[0018]

(7) A step of connecting a driver circuit and a polarizing means to the liquid crystal cell and modularizing the liquid crystal cell.

[0019]

Means 1 provides a method for obtaining an active matrix liquid crystal display device which has higher image quality without display unevenness in such a manner that an active element, a horizontal electric field mode, and an alignment film formed using a polymer soluble in a solvent, on which treatment can be performed in a process at a lower temperature, are combined with each other.

[0020][Means 2]

The manufacturing method of a liquid crystal display device described in Means 1, characterized in that the active element is a thin film transistor element.

[0021][Means 3]

The manufacturing method of a liquid crystal display device described in Means 1, characterized in that the polymer soluble in a solvent is polyimide.

[0022] [Means 4]

The manufacturing method of a liquid crystal display device described in Means 1, characterized in that the polymer soluble in a solvent is polyamide.

[0023]

Means 2 to Means 4 provide a more favorable means of the active element and a polymer soluble in a solvent. A thin film transistor element is excellent as an active element. Further, polyimide and polyamide are especially excellent among dense and macromolecular alignment films with high ability of liquid crystal alignment.

[0024][Means 5]

The manufacturing method of a liquid crystal display device described in Means 1, characterized in that the substrate of the pair of substrates, which faces to the substrate having the matrix element, is subjected to the (2) to (4) steps.

[0025][Means 6]

The manufacturing method of a liquid crystal display device described in Means 5, characterized in that a color filter is formed over the substrate which faces to the substrate having the matrix element, and color-developing ability of a plurality of colors is imparted to the liquid crystal cell.

[0026][Means 7]

The manufacturing method of a liquid crystal display device described in Means 1, characterized in that the substrate having the matrix element, of the pair of substrates, is subjected to the (2) to (4) steps.

[0027][Means 8]

The manufacturing method of a liquid crystal display device described in Means 7, characterized in that a color filter is formed over the substrate having the matrix element and color-developing ability of a plurality of colors is imparted to the liquid crystal cell.

[0028]

Means 5 to Means 8 provide a means in which the polymer soluble in a solvent is limited to be formed over one of the substrates.

[0029][Means 9]

The manufacturing method of a liquid crystal display device described in Means 6 or 8, characterized by including the following steps.

[0030]

(1) A step of forming a film having a plurality of color developing layers.

[0031]

(2) A step of forming a color filter by irradiation with a light pattern including a plurality of colors.

[Means 10] The manufacturing method of a liquid crystal display device described in Means 9, characterized in that a light irradiation step is performed once.

[0032][Means 11]

The manufacturing method of a liquid crystal display device described in Means 9 or 10, characterized in that after forming a color filter by irradiation of a film including the color developing layer which is interposed between a pair of macromolecular protective films with a light pattern, the film is attached over one of the substrates.

[0033]

Means 9 to Means 11 provide a manufacturing method of a color filter by a photographic method which realizes brighter colors and has not been able to be used due to existence of a high temperature heating process in a subsequent step of forming an alignment film in the conventional technique.

[0034][Means 12]

The manufacturing method of a liquid crystal display device described in Means 6 or 8, characterized in that light-shielding layers which block boundary portions of a plurality of color filters are formed over at least one of the pair of substrates at the time of assembling the liquid crystal cell.

[0035][Means 13]

The manufacturing method of a liquid crystal display device described in the means 12, characterized in that the light-shielding layer is formed over the substrate having the matrix element, and the plurality of color filters is formed over the substrate which faces to the matrix element.

[0036][Means 14]

The manufacturing method of a liquid crystal display device described in Means 12, characterized in that the light-shielding layer and the plurality of color filters are formed over the substrate having the matrix element.

[0037]

The means 12 to the means 14 provides a method for obtaining a light-shielding layer with a

higher light-shielding property and an active matrix liquid crystal display device which has higher image quality.

[0038]

[Operation]

(1) The principle of operation of a horizontal electric field mode

First, the principle of operation of a horizontal electric field mode which is an essential structure of the present invention is described. FIG. 2 shows definitions of an angle ϕ_{LC} formed by a liquid crystal molecule major axis (an optical axis) direction 10 in the vicinity of an interface with respect to an electric filed direction 9 and an angle ϕ_P formed by a polarized light transmission axis 11 of a polarizing plate. Since there are a pair of polarizing plates and a pair of liquid crystal interfaces above and below, angles thereof are denoted by ϕ_{P1}, ϕ_{P2}, ϕ_{LC1}, and ϕ_{LC2} as necessary. Note that FIG. 2 corresponds to a front view of FIG. 1 to be described later.

[0039]

FIGS. 1 (a) and (b) are sectional side views showing operation of a liquid crystal in a liquid crystal panel of the present invention, and FIGS. 1 (c) and (d) are front views thereof. In FIG. 1, a thin film transistor element portion is omitted and part of a wiring electrode structure is shown. Further, a display device of the present invention includes a plurality of pixels; however, only part of one pixel is shown. FIG. 1 (a) is a sectional side view of a cell at the time of applying no voltage, and FIG. 1(c) is a front view at that time. Linear electrodes 1 and 4 are formed inside a pair of transparent substrates, and a protective insulating film 5 is applied thereover and is subjected to alignment treatment. In the protective insulating film 5 shown in this drawing, a protective film and an alignment control film are drawn to be integrated, both of which may be formed using a single material or may be stacked using two materials. A liquid crystal composition is interposed therebetween. A stick liquid crystal molecule 6 is aligned such that it has a slight angle, that is, 45 degrees $\leq |\phi_{LC}| < 90$ degrees with respect to a longitudinal direction (FIG. (c) which is a front view) of the electrodes 1 and 4 at the time of applying no electric filed. In FIG. 1 and FIG. 2, the liquid crystal molecule major axis alignment direction (a rubbing direction) 10 above the interfaces is shown by an arrow. The liquid crystal molecule alignment directions above upper and lower interfaces are parallel, that is, $\phi_{LC1} = \phi_{LC2}$ $(=\phi_{LC})$, as a favorable example. Dielectric anisotropy of the liquid crystal composition is assumed to be positive.

[0040]

Here, a different potential is applied to each of the pixel electrode 4 and the common electrode 1, a potential difference is applied therebetween, and an electric field is applied to the liquid crystal composition layer in the electric filed direction 9, whereby the liquid crystal molecules react and the directions thereof are changed in the electric filed direction by interaction between dielectric anisotropy of the liquid crystal composition and the electric field as shown in FIGS. 1 (b) and (d). Brightness changes by interactions between refractive index anisotropy of the liquid crystal composition layer and the polarizing plate.

[0041] (2) Flexibility of selecting in an alignment film material and a liquid crystal material

Next, operation on increase in flexibility of selecting in an alignment film material and a liquid crystal material by employing a horizontal electric field mode which is an essential structure of the present invention is described. As described in "Problems to be solved by the invention", in selecting an alignment film material and a liquid crystal material, the following three points need to be taken into consideration: (1) precise control of the interface, (2) maintenance of high purity of liquid crystal, and (3) suppression of afterimage phenomenon. Hereinafter, as for these three points, an effect of converting a vertical electric field mode into a horizontal electric field mode is described sequentially.

[0042]

In a vertical electric field mode, optical switching is performed in such a manner that liquid crystal molecules, which are almost parallel to substrate surfaces at the time of a low electric field, are made to rise by a dielectric interaction between an electric field in a direction perpendicular to the substrate surfaces (a vertical electric field) and the liquid crystal molecules. At this time, if a tilt angle is completely zero, there exist two kinds of tilt directions and a boundary between the two kinds domains becomes an alignment defect region (referred to as reverse tilt domain), which causes significant decrease in image quality. In an actual element, the vicinity of an end portion of a pixel has many steps which are made by a wiring electrode, a thin film transistor, and the like. Therefore, when a large tilt angle of about 4 degrees is not obtained, this reverse tilt domain cannot be suppressed. The tilt angle in a vertical electric field mode needs because one tilt direction of the liquid crystal molecules at the time of application of the electric field needs to be determined in advance. In other words, an angle between the electric filed direction and the initial liquid crystal molecule alignment direction should be sufficiently less than 90 degrees. This angle is empirically at least less than or equal to 88.5 degrees, preferably less than or equal to

86 degrees. That is, when being converted into a tilt angle, it is at least greater than or equal to 1.5 degrees, preferably greater than or equal to 4 degrees. On the other hand, in a case of a horizontal electric field mode, a rule of "an angle between the electric filed direction and the initial liquid crystal molecule alignment direction should be sufficiently less than 90 degrees in order to prevent an alignment defect region" can be applied. Accordingly, since the electric filed direction is changed from a vertical direction to a horizontal direction, an angle which corresponds to the tilt angle in a vertical electric field mode is in an alignment direction of liquid crystal molecules in the substrate surface, and thus, the angle between the interfaces and the liquid crystal molecules is not a matter and may be completely zero. The tilt angle is determined by an interaction between the alignment film and the liquid crystal molecules at a molecular level, while the alignment direction of liquid crystal molecules in the substrate surface is determined by a parameter of a rubbing direction which can be set freely at a design phase. Although described in a single phrase of "an interaction between the alignment film and the liquid crystal molecules at a molecular level", the phenomenon is complicate, and not only a primary structure of a material but also a secondary structure such as molecular conformation are related, and thus, a dependency on process conditions cannot be avoided. Accordingly, employing a horizontal electric filed mode completely release the restrictions of the tilt angle, and even by only this one point, flexibility of selecting in a material and a process is significantly increased. In the present invention, a process is used in which a macromolecular alignment film which has been already polymerized is dissolved in a solvent and applied, and thus, it is not necessary to generate a polymerization reaction over the substrate and a dense film quality with macromolecule can be obtained regardless of process fluctuation. The effect of suppressing the domain and the display unevenness also contributes to improvement of utilization efficiency of light. That is, the alignment defect portion which is generated in the vicinity of a portion having a step like a thin film transistor has been shielded with a black matrix in the conventional technique; however, in this mode, the area of the light-shielding portion can be reduced. As a result, the aperture ratio is improved, and accordingly, the utilization efficiency of light is improved, so that an effect of obtaining brighter display can also be obtained.

[0043]

Next, operation that the flexibility of a horizontal electric filed mode significantly increases also in maintaining high purity of liquid crystal which is a second request is described. In an active

matrix liquid crystal display device such as a thin film transistor liquid crystal display device, an image information signal is applied to a liquid crystal only in a scanning selection time and the pixel portion is open in a nonselection time in which another line is selected in terms of a circuit. In this period, a charge supplied from a signal wiring electrode has to be held for a period by a time when the line is selected next (one frame period). A time constant of a period of holding this charge is determined mainly by a product of electrostatic capacitance and electric resistance of the entire pixel portion. However, in the case of a vertical electric filed mode, even when the value of the electric resistance is a maximum value which the liquid crystal can realize, only electrostatic capacitance which the liquid crystal itself has is insufficient, and practically, a wiring or the like is led to add a capacitor portion for each pixel. On the other hand, in the case of a vertical electric field mode, the electrodes are provided linearly and a cross-sectional area in a direction perpendicular to the electric filed direction which determines the resistance value becomes significantly small. Therefore, even when resistivity of the liquid crystal composition is the same, the resistance value of the liquid crystal pixel portion can be significantly reduced. On the other hand, the capacitor is in the inverse ratio of the resistance value to be smaller, which is disadvantageous. However, increase in the resistance value is significant (greater than or equal to 100 times), and thus, by combining the added capacitor which has been formed in the conventional technique, sufficient voltage can be held. If an added capacitor element which is the same or almost the same as a conventional capacitor element is provided, there is no problem even when the resistance value of the liquid crystal is decreased to be one tenth or one hundredth. In this manner, contamination resistance of liquid crystal is significantly improved, whereby flexibility of selecting in a peripheral material of not only liquid crystal itself but also an alignment film which is in contact with a liquid crystal, a sealing material, a sealant, or the like and process tolerance for forming them are significantly increased. In the step of applying the polymer soluble in a solvent of the present invention in a solution state, conventional high temperature heating is unnecessary, and the surface state is made uniform easily. Further, even when a liquid crystal is contaminated a little due to seepage of remaining solvent or the like, voltage holding ratio is not reduced, and in this point, display unevenness is not likely to be caused.

[0044]

The present invention has a significant effect of suppressing an afterimage phenomenon which is

a third request. The afterimage phenomenon is also a phenomenon in which an interface phenomenon is recognized. In general, the interface phenomenon occurs as a property in a direction perpendicular to the interface. In the case of a horizontal electric field mode, a main component of the electric field is parallel to the interface and such an interface phenomenon is not likely to be caused at all. In fact, as described in an embodiment later, in any of embodiments, no afterimage phenomenon was caused.

[0045]

By the three effects described above, various display unevenness to which the interface phenomenon and slight contamination in the liquid crystal are related is suppressed, so that an even liquid crystal display device with high image quality can be realized. In addition, a new process which has not been able to be performed at all before now becomes possible. That is, flexibility of selecting in a material of an alignment film, a sealing material, a sealant, or the like is increased, which leads to large reduction in a heating temperature and reduction in heating process time, for example. Further, a material for a color filter, light shielding, or the like which is a peripheral material that has not been able to be used due to restrictions of heat resistance, ability to prevent contamination, or the like can be used. As a result, a composition material which can suppress display unevenness and improve an image quality significantly can be selected. By utilizing the characteristics of a horizontal electric filed mode, the present invention provides a method by which a polymer which has higher tolerance, which is soluble in a solvent and to which a low temperature process can be applied, is employed as an alignment film material, and a film quality of an alignment film is stabilized, so that a liquid crystal display device without display unevenness is obtained. In addition, application of a low cost process such as significant reduction in a heating temperature or reduction in a heating process time leads to significant reduction in production power and contributes to reduction in manufacturing cost and saving of energy resource.

[0046]

[Embodiment] The present invention is described specifically by embodiments.

[0047]

[Embodiment 1]

Two transparent glass substrates each of which has a thickness of 1.1 mm and each surface of which is polished are used. First, a thin film transistor was formed over one of these substrates

in the following procedure. Note that a matrix element including the thin film transistor and a wiring electrode may be any kind as long as a horizontal electric field can be applied, and a manufacturing method thereof is not related to an essential feature of the present invention; therefore, a description thereof is simplified. The description here relating to the manufacturing method of the matrix element is an example, and this embodiment is not limited thereto. Hereinafter, this embodiment is described with reference to FIG. 7, FIG. 8, and FIG. 9 which show schematically a cross-sectional view taken along line C-C' of FIG. 3 showing a structure of one pixel.

[0048]

A chromium film was formed over one of surfaces of a transparent glass substrate 7 by a sputtering method, and next, a scan electrode 12 and a common electrode 1 were patterned by a photolithography method (FIG. 7 (a)). After that, a gate insulating film formed using silicon nitride (SiN) was formed thereover by a CVD (Chemical Vapor Deposition) method (FIG. 7 (b)), and a-Si 13 of which surface layer is an n-type amorphous silicon (a-Si) film was formed thereover also by a CVD method (FIG. 7 (c)). A signal electrode 3 and a pixel electrode 4 formed using chromium were formed by a sputtering method or a photolithography method so as to cover part of the a-Si 13 to form a thin film transistor (FIG. 7 (d)). An insulating protective film formed using SiN was formed thereover (FIG. 8 (e)). After that, a light-shielding layer 22 and a color filter 23c which serves as a pigment were formed thereover, and a planarization film 23b formed using a resin was spin-coated thereover (FIG. 8 (f)). As the light-shielding layer, an epoxy resin in which a carbon particle manufactured by Cabot Corporation (MONARCH 800, a grain size of 16 nm) is mixed by 1 weight% was used. As color developing pigments of the color filter, with respect to three primary colors of red, green, and blue, CR-6101, CG-5101, and CB-6101 manufactured by FUJIFILM Hunt Chemicals were used, respectively. After application is performed by spin coating and prebake is performed at 85 °C, exposure to light and development are performed, and lastly, postbake is performed at 200 °C, whereby a film-shaped color filter was formed. In this embodiment, a pigment was used as a color developing layer; however, since heating does not need to be performed at a high temperature in a subsequent alignment film formation process according to the present invention, a dye type coloring agent which has low heat resistance and a vivider color may be used. Further, as a material for a light-shielding layer, in this embodiment, a material which may be a contamination source which

lowers resistivity of a liquid crystal, such as a carbon black particle, was used; however, since a horizontal electric field mode itself is resistant to contamination, there is no problem. Rather, since a carbon black particle excels in a light-shielding rate, a higher image quality can be realized. Needless to say, there causes no problem even when other insulating light shielding materials such as a pigment and dye except a carbon black particle are used. Further, although an epoxy resin was used as a resin thereover for planarization, this is not limited to this material. Next, a polymer solution 24a of AL-1051 (manufactured by JSR corporation) which is a solvent-soluble type polyimide with imidization ratio of 100 % was applied by a spin coating method (FIG. 8 (g)). In this embodiment, as a solvent, a solution where dimethylformamide which is a polar solvent and butyl cellsolve which is a non-polar solvent were mixed so as to have a weight ratio of 8 :2 was used; however, in a case of a polar solvent, *N*-methyl-2-pyrrolidone or dimethylacetamide may be used instead of dimethylformamide, and in a case of a non-polar solvent, butylcellosolve acetate may be used. Further, although a spin coating method was employed as a coating method in this embodiment, the embodiment is not limited thereto as long as a method by which coating can be performed to have a uniform thickness, such as various printing methods such as letterpress printing, offset printing, screen printing, a roll coating method, a dipping method, or the like is employed. After that, this solution was heated to 160 °C, was left for 30 minutes, and the solvent was removed. In this manner, a polymer 24b which was a dense polyimide alignment film was obtained (FIG. 8 (h)). Next, this surface was subjected to rubbing treatment, so that ability of liquid crystal alignment was imparted to the surface of the alignment film (FIG. 9 (i)). In this embodiment, as a method for imparting the alignment ability, a rubbing method was employed; however, other methods such as a method of forming a minute groove can also be utilized. Next, the counter substrate in which ability of a liquid crystal alignment was imparted to the surface of the alignment film using the same material and the same process, and the surfaces 24d each having ability of a liquid crystal alignment face each other and the cell was assembled with the spacer formed using a polymer particle and the sealing material of the peripheral portion interposed therebetween (FIG. 9 (j)). A liquid crystal molecules 6 were injected into this cell in vacuum and sealing was performed with a sealant 28 containing an ultraviolet curable resin. After that, a driver circuit, a polarizing plate, a backlight, and the like were connected to this cell and this cell was modularized, so that a liquid crystal display device was obtained.

[0049]

Next, a structure of the liquid crystal display device obtained through such a process is described more specifically.

[0050]

Rubbing directions on the interfaces above and below were made almost parallel to each other, and an angle between the rubbing directions and an applied electric field direction was set to be 88 degrees ($\phi_{LC1} = \phi_{LC2} = 88°$). The dielectric anisotropy $\Delta\varepsilon$ of a nematic liquid crystal compound interposed between these substrates is positive, value thereof is 4.5, and the refractive index anisotropy Δn is 0.072 (589 nm, 20 °C). Further, although the resistance value of this liquid crystal composition was greater than or equal to 10^{14} Ω·cm at first, this liquid crystal composition was contaminated after that, and the resistance value thereof was reduced to be 6×10^{12} Ω·cm. In this embodiment, this contaminated liquid crystal composition was used. The gap d was set to be 3.9 μm in a state where the liquid crystal was filled and sealed in such a manner that spherical polymer particles were dispersed and held between the substrates. Accordingly, the product of $\Delta n \cdot d$ was 0.281 μm. Further, when the same alignment film material was formed over a glass substrate in the same process and the tilt angle of the liquid crystal molecule major axis was measured by a crystal rotating method, it was only 1.2 degrees. A panel was interposed between two polarizing plates (G1220DU manufactured by NITTO DENKO CORPORATION), the polarized light transmission axis of one of the polarizing plates was set to be an angle slightly smaller than the rubbing direction, that is, $\phi_{p1} = 80°$ (that is, $|\phi_{LC1} - \phi_{P1}| = 8°$), and the polarized light transmission axis of the other of the polarizing plates was set to be orthogonal thereto, that is, $\phi_{p2} = -12°$. Thus, characteristics (FIG. 4) were obtained in which, as the voltage V_{LC} applied to a pixel was gradually increased from zero, brightness is reduced to the minimum value. In this embodiment, normally close characteristics were employed in which a dark state was obtained at a low voltage (V_{OFF}) and a bright state was obtained at a high voltage (V_{ON}). V_{OFF} is 6.9V and V_{ON} is 9.1V.

[0051]

Structures of a thin film transistor and various electrodes are shown in FIG. 3 and the detail description is made. FIG. 3 (a) is a front view seen from a direction perpendicular to the substrate surface, and FIGS. 3 (b) and 3 (c) are cross-sectional side views. A thin film transistor 14 includes a pixel electrode (a source electrode) 4, a signal electrode (a drain electrode) 3, a scan

electrode (a gate electrode) 12, and an amorphous silicon 13. The common electrode 1 and the scan electrode 12 were patterned and formed using the same metal layer, and the signal electrode 3 and the pixel electrode 4 were patterned and formed using the same metal layer. A capacitor 16 was formed so as to have a structure in which a gate insulating film 2 was interposed between the pixel electrode 4 and the common electrode 1 in a region connecting two common electrodes 1 (shown by dotted lines in FIG. 3). The pixel electrode 4 is provided between the two common electrodes 1 in the front view (FIG. 3 (a)). One pixel pitch 15 is 69 μm in a horizontal direction (that is, between the signal electrodes), and is 207 μm in a vertical direction (that is, between the scan electrodes). The widths of the scan electrode, a signal electrode, a common electrode wiring portion (portion which are extended parallel to the scan electrode (in a horizontal direction in FIG. 3)) which are wiring electrodes, which are ranging between a plurality of pixels, was increased, so that a line defect was prevented. Each width was 10 μm. On the other hand, the widths of portions which extend to the longitudinal directions of the pixel electrode and the signal wiring electrode of the common electrode, were slightly reduced, and each width was 5 μm and 8 μm. Although reduction in widths of these electrodes increases a possibility of disconnection due to contamination of a foreign substance, in this case, only a partial defect of one pixel is caused and a line defect is not caused. In addition, in order to realize an aperture ratio as high as possible, the common electrode and the signal electrode were slightly overlapped (1 μm) with the insulating film interposed therebetween. Thus, a black matrix in a direction parallel to the signal wiring is not necessary. Therefore, as shown in FIG. 3 (c), a black matrix structure was employed in which light shielding was performed only in the direction of the scan electrode. In this manner, the gap between the common electrode and the pixel electrode was 20 μm and the length of the aperture in a longitudinal direction was 157 μm, so that a high aperture ratio of 44.0 % was obtained. The number of pixels was 320 × 160 with 320 signal electrodes and 160 scan electrodes. In FIG. 5 and FIG. 6, panels each including a plurality of pixels are shown. In FIG. 5, a black matrix is omitted, and in FIG. 6, a state in which light shielding is performed with the black matrix is shown.

[0052]

Next, a circuit configuration and a driving waveform are described. Each scan electrode 12 and each signal electrode 3 were connected to a signal electrode driver circuit 18 and a scan electrode driver circuit 19, respectively. Further, a common electrode driver circuit 20 was connected to

the common electrode 1 (FIG. 13). A signal waveform having information is applied to the signal electrode 3, and a scan waveform is applied to the scan electrode 12, synchronizing the signal waveform. An information signal is transmitted from the signal electrode 3 to the pixel electrode 4 through the thin film transistor element 14, and a voltage is applied to the liquid crystal between the common electrode 1 and the liquid crystal. In FIG. 14, specific examples of driving voltage waveforms are shown. Note that the amplitude in the case of this embodiment was set to satisfy $V_{D\text{-}CENTER} = 14.0$, $V_{GH} = 28.0$, $V_{GL} = 0$, $V_{DH} = 15.1$, $V_{DL} = 12.9$, $V_{CH} = 20.4$, and $V_{CL} = 4.39$, and as a result of this, a jump voltage ΔV_{GS} (+), V_{GS} (−), a voltage V_S applied to the pixel electrode, and a voltage V_{LC} applied to the liquid crystal due to parasitic capacitance between a gate electrode and a source electrode were as in the following table. Note that the unit of voltage is "volt" hereinafter.

[0053]

[Table 1]

Various voltage values

Display state	ΔV_{GS} (+)	V_{GS} (−)	V_{SH}	V_{SL}	V_{LCH}	V_{LCL}	V_{rms}
Brightness	+1.76	−1.64	+11.14	−13.46	+9.24	−9.07	9.16
Darkness	+1.47	−1.57	+13.63	−11.33	+6.75	−6.94	6.85

[0054]

V_{ON} and V_{OFF} shown in FIG. 4 were 9.16 volts and 6.85 volts, respectively. In this embodiment, a process temperature for forming the alignment film was set to be 160 °C at which the solvent can be removed sufficiently and which is a temperature much lower than conventional one. Further, the tilt angle was 1.2 degrees, which is a value low enough to cause an alignment defect in the conventional vertical field effect mode; however, no alignment defect such as reverse tilt domain was caused. Furthermore, an effect of reduction in the tilt angle is that there was no alignment nonuniformity and display uniformity was also increased. In measuring display performance with a luminance meter, a sufficiently high contrast ratio 80 was obtained. In addition, there was no display unevenness at all due to contamination of the liquid crystal, or the like and display with high uniformity was obtained. Moreover, when a fixed pattern was displayed for one hour and then changed to another pattern, no afterimage (burn-in) phenomenon was recognized and the fixed pattern was changed to the new pattern instantly.

[0055]

[Embodiment 2]

In this embodiment, HTX-6700 (Manufactured by Hitachi Chemical Co., Ltd), which is a solvent-soluble type polyamide, was used as an alternative to the polyimide alignment film of Embodiment 1. As with Embodiment 1, after a polyamide was applied in a solution state, this solution was heated to 150 °C, it was left as it was for 30 minutes, and the solvent was removed, so that a dense polyamide alignment film was obtained. The tilt angle was 1.0 degrees. Other structures are the same as those of Embodiment 1. When modularization was performed and characteristics thereof was evaluated, a sufficiently high contrast ratio 100 was obtained, and no alignment defect such as alignment nonuniformity or reverse tilt domain or no display unevenness due to contamination of the liquid crystal, or the like was caused, so that display with high uniformity was obtained. Moreover, when a fixed pattern was displayed for one hour and then changed to another pattern, no afterimage (burn-in) phenomenon was recognized and the fixed pattern was changed to the new pattern instantly.

[0056]

[Comparative Example 1]

An alignment film was formed over a conventional thin film transistor matrix substrate for a vertical electric field mode in a manner similar to that of Embodiment 2. A color filter was formed under a transparent conductive film formed on a counter substrate. As a display mode, a twisted nematic mode was employed. Further, as a liquid crystal material, a material which is not contaminated and has a resistance value of $10^{14}\Omega\cdot\text{cm}$ was used. Other than these regards were the same as Embodiment 2.

[0057]

As a result, an alignment defective domain was generated in an end portion of a pixel due to the shortage of the tilt angle, a light scattering phenomenon occurs, and the contrast ratio was reduced to 25:1. In addition, display unevenness which appears at the time of using a contaminated liquid crystal was also generated.

[0058]

[Embodiment 3]

In this embodiment, a color filter was formed on a counter substrate side. FIG. 10 shows a cross-sectional schematic view of a liquid crystal display device of this embodiment. A color

filter 23c having a plurality of colors is stacked on a counter substrate 7 side. Boundaries of the plurality of colors are provided just over a light-shielding layer 22 over a matrix substrate. A width of a light-shielding portion is 50 μm, which is very large as compared to 3 to 10 μm of alignment accuracy between substrates of a general liquid crystal panel assembling apparatus; therefore, assembling can be performed very simply. Further, the color filter of this embodiment was manufactured in such a manner that light irradiation is performed once on FUJICHROME, PROVIA, 100DAY LIGHT, RDPII135, which is a positive type film manufactured by FUJIFILM Corporation, to form a pattern of the plurality of colors. Since the film has a plurality of color developing layers between two protective films in advance, when light irradiation is performed through a photomask corresponding to a pattern of a color which is needed as a liquid crystal display device, a color filter can be obtained by performing light irradiation once. After this color filter was bonded to the counter substrate with an epoxy-based adhesive at a room temperature while a pressure being applied, a cell was obtained through an alignment film formation process similar to Embodiment. At this time, the solvent was removed at 80 °C under reduced pressure of 10 mm Hg for five hours. The other conditions are similar to those of Embodiment 2.

[0059]

When modularization was performed and the characteristics thereof was evaluated, sufficiently high contrast ratio 100 was obtained, and there was no display unevenness due to no alignment nonuniformity, alignment defect such as reverse tilt domain, contamination of liquid crystal, or the like, so that display with high uniformity was obtained. Moreover, when a fixed pattern was displayed for one hour and then changed to another pattern, no afterimage (burn-in) phenomenon was recognized and the fixed pattern was changed to the new pattern instantly. In addition, a color tone of a color filter manufactured using such a positive type film is very vivid, so that a color of the liquid crystal display device of the present invention using this also becomes vivid.

[0060]

Note that in this embodiment, the color developing layer which are sandwiched between the protective films was used, and after formation of a color filter pattern, the color developing layer was bonded to a glass substrate; however, the coloring developing layer may be formed over the glass substrate from the beginning. Further, it is preferable to perform light exposure once in terms of a manufacturing cost; however, it may be performed plural times.

[0061]

[Embodiment 4]

In this embodiment, a color filter was manufactured using EKTACHROME DYNA 100, which is a positive type film manufactured by KODAK JAPAN LTD., in a process similar to that of Embodiment 3. Further, a light-shielding layer was provided for a pattern of a color filter and was not formed in an active element. FIG. 12 shows an arrangement of a light-shielding layer in a color filter of this embodiment. FIG. 12 (a) shows a sectional side of the pattern, and FIG. 12 (b) shows the pattern seen from the front.

[0062]

Similarly, when it was modularized and the characteristics thereof was evaluated, sufficiently high contrast ratio 90 was obtained, and there was no display unevenness due to no alignment nonuniformity, alignment defect such as reverse tilt domain, contamination of liquid crystal, or the like, so that display with high uniformity was obtained. Moreover, when a fixed pattern was displayed for one hour and then changed to another pattern, no afterimage (burn-in) phenomenon was recognized and the fixed pattern was changed to the new pattern instantly. As with Embodiment 3, a color tone of a color filter manufactured using such a positive type film is very vivid, so that a color of the liquid crystal display device of the embodiment using this also becomes vivid.

[0063]

Through Embodiments 1 to 4 described above, by employing a horizontal electric field mode and a polymer which is soluble in a solvent as an alignment film in an active element such as a thin film transistor element, tolerance to contamination of a liquid crystal or tolerance to an alignment process, such that a heating temperature may be low after application of an alignment film varnish, is increased, and a liquid crystal display device which has high image quality without display unevenness was obtained.

[0064]

[Effect of the Invention]

According to the present invention, by combining a horizontal electric field mode and a polymer which is soluble in a solvent and of which heat temperature may be low after application in an active matrix element such as a thin film transistor element, tolerance to contamination of a liquid crystal or an alignment process is increased, and a liquid crystal display device which has high

image quality without display unevenness can be obtained.

[Brief Description of the Drawings]

[FIG. 1] Views showing operation of a liquid crystal in a liquid crystal display device of the present invention.

[FIG. 2] View showing angles between molecule major axis direction (a rubbing direction) ϕ_{LC} over the interfaces and a direction of a polarized light transmission axis of a polarizing plate ϕ_P with respect to an electric filed direction.

[FIG. 3] Views showing a structure of a thin film transistor, an electrode, and a wiring of a liquid crystal display device of the present invention [(a) front view, (b) and (c) sectional side views]

[FIG. 4] Graph showing electro-optical characteristics of a liquid crystal display device of the present invention.

[FIG. 5] View showing an arrangement of a plurality of pixels of a liquid crystal display device of the present invention.

[FIG. 6] View showing an arrangement of a plurality of pixels of a liquid crystal display device of the present invention.

[FIG. 7] Views showing a manufacturing process of a liquid crystal display device of the present invention.

[FIG. 8] Views showing a manufacturing process of a liquid crystal display device of the present invention.

[FIG. 9] Views showing a manufacturing process of a liquid crystal display device of the present invention.

[FIG. 10] Cross-sectional side view of a liquid crystal display device of the present invention, on which a color filter is mounted.

[FIG. 11] View showing a manufacturing method of a color filter of a liquid crystal display device of the present invention.

[FIG. 12] Another embodiment of a color filter of a liquid crystal display device of the present invention.

[FIG. 13] View showing a circuit of a liquid crystal display device of the present invention.

[FIG. 14] Views showing another driving waveform of a liquid crystal display device of the present invention.

[Description of the Numerals]

1: Common electrode, 2: Gate insulating film, 3: Signal electrode (Drain electrode), 4: Pixel electrode (Source electrode), 5: Protective insulating film, 6: Liquid crystal molecule in liquid crystal composition layer, 7: Substrate, 8: Polarizing plate, 9: Electric field direction, 10: Molecule major axis direction (a rubbing direction) over the interfaces, 11: Direction of a polarized light transmission axis of a polarizing plate, 12: Scan electrode (Gate electrode), 13: Amorphous silicon, 14: Thin film transistor element, 15: One pixel pitch, 16: Added capacitor element portion, 17: A control circuit, 18: Signal electrode driver circuit, 19: Scan electrode driver circuit, 20: Common electrode driver circuit, 21: Display region, 22: Light-shielding layer, 23a: Color developing layer, 23b: Planarization film, 23c: Color filter, 23d: Macromolecular protective film, 24a: Polymer solution, 24b: Polymer, 24c: rubbing roller, 24d: Alignment film, 25: Photomask, 26: Light, 27: Sealing material, 28: Sealant

Continued from the front page

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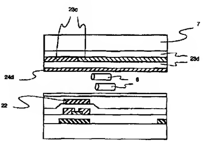
(54)【発明の名称】　液晶表示装置の製造方法

(57)【要約】
【目的】液晶の汚染や、配向プロセスに対する裕度が高い、表示むらのない高画質の液晶表示装置の製造方法を得る。
【構成】横電界を印加する電極構造を有するアクティブマトリクス素子の配向膜を、溶剤に溶融するポリマを用い低温で形成することで、低表示むら液晶表示装置を得る。

図 10



【特許請求の範囲】

【請求項1】以下の工程からなることを特徴とする液晶表示装置の製造方法。

（1）セルを構成する一対の基板の一方の基板上に走査電極，共通電極，走査電極と交差する信号電極，アクティブ素子，画素電極を有し、該画素電極と該共通電極が主として液晶に対して基板面に平行な電界を印加するように配置されたマトリクス素子を形成する工程。

（2）該基板上に、溶剤に可溶なポリマの溶液を塗布する工程。

（3）該ポリマの溶液中の溶剤を除去する工程。

（4）該ポリマの表面に液晶分子配向能を付与する工程。

（5）表面に液晶分子配向能を有する一対の基板をスペーサと基板周辺部に形成されたシール部とを介して、液晶分子配向能を有する表面どうしを相対向させてセルを組み立てる工程。

（6）該セルに液晶組成物を注入，封止し液晶セルを形成する工程。

（7）該液晶セルに駆動回路，偏光手段を接続しモジュール化する工程。

【請求項2】前記アクティブ素子が薄膜トランジスタ素子であることを特徴とする請求項1に記載の液晶表示装置の製造方法。

【請求項3】前記溶剤に可溶なポリマがポリイミドであることを特徴とする請求項1に記載の液晶表示装置の製造方法。

【請求項4】前記溶剤に可溶なポリマがポリアミドであることを特徴とする請求項1に記載の液晶表示装置の製造方法。

【請求項5】前記一対の基板のうち前記マトリクス素子を有する基板に対向する基板が(2)から（4）の工程を経ることを特徴とする請求項1に記載の液晶表示装置の製造方法。

【請求項6】前記マトリクス素子を有する基板に対向する基板上にカラーフィルタを形成し、液晶セルとして複数の発色能を付与したことを特徴とする請求項5に記載の液晶表示装置の製造方法。

【請求項7】前記一対の基板のうち前記マトリクス素子を有する基板が（2）から（4）の工程を経ることを特徴とする請求項1に記載の液晶表示装置の製造方法。

【請求項8】前記マトリクス素子を有する基板上にカラーフィルタを形成し、液晶セルとして複数の発色能を付与したことを特徴とする請求項7に記載の液晶表示装置の製造方法。

【請求項9】以下の工程からなることを特徴とする請求項6あるいは8に記載の液晶表示装置の製造方法。

（1）複数の発色層を有する膜を形成する工程。

（2）複数の色からなる光パターンを照射しカラーフィルタを形成する工程。

【請求項10】光照射工程が1回であることを特徴とする請求項9に記載の液晶表示装置の製造方法。

【請求項11】1対の高分子保護膜で挟まれた前記発色層からなるフィルムに光パターンを照射しカラーフィルタを形成した後、前記一方の基板上に該フィルムを貼付けすることを特徴とする請求項9あるいは10に記載の液晶表示装置の製造方法。

【請求項12】前記液晶セル組立て時に複数のカラーフィルタの境界部を遮光する遮光層を前記一対の基板の少なくとも一方の基板上に形成することを特徴とする請求項6あるいは8に記載の液晶表示装置の製造方法。

【請求項13】前記マトリクス素子を有する基板上に前記遮光層を形成し、前記マトリクス素子に対向する基板上に前記複数のカラーフィルタを形成することを特徴とする請求項12に記載の液晶表示装置の製造方法。

【請求項14】前記マトリクス素子を有する基板上に前記遮光層と前記複数のカラーフィルタを形成することを特徴とする手段12に記載の液晶表示装置の製造方法。

【発明の詳細な説明】

【0001】

【産業上の利用分野】本発明は、表示むらのない高画質のアクティブマトリクス型液晶表示装置の製造方法に関する。

【0002】

【従来の技術】従来のアクティブマトリクス型液晶表示装置では、液晶層を駆動する電極としては2枚の基板界面上に形成し相対向させた透明電極を用いていた。これは、液晶に印加する電界の方向を基板界面にほぼ垂直な方向とすることで動作する、ツイステッドネマチック表示方式に代表される表示方式（以後縦電界方式と呼ぶ）を採用していることによる。一方、液晶に印加する電界の方向を基板界面にほぼ平行な方向とする方式（以後横電界方式と呼ぶ）として、櫛歯電極対を用いた方式が、例えば特公昭63−21907 号公報により提案されているが、表示装置としては実用化されていない。

【0003】

【発明が解決しようとする課題】従来の縦電界方式を用いたアクティブマトリクス型液晶表示装置では、縦電界方式を用いたことによる以下のような数々の問題が生じ、その結果表示むらのない高画質の液晶表示装置を得ることが困難であった。

【0004】（1）界面の精密な制御

縦電界方式と薄膜トランジスタのような微細なアクティブマトリクス素子を組み合わせると、界面状態の僅かな変動が表示むらを引き起こす。例えば、配向膜の表面状態が変動すると液晶分子長軸と界面とのなす角（傾き角）も変動し、それにより電圧印加に対する液晶の応答性が変わり明るさが変わる。

【0005】配向膜の表面状態は配向膜形成プロセス条件に微妙に依存し、プロセス条件の厳密なコントロール

が要求されている。例えば、ポリイミド配向膜の場合、基板上に低分子量のポリイミド前駆体溶液を塗布した後、順次加熱することにより溶剤の乾燥に加えて、重合反応の促進により高分子量の緻密で均一な表面状態を有する膜が形成される。特に重合反応促進のための加熱温度は例えば２００℃以上と非常に高い。この際、この高温の加熱条件が変動すると、傾き角が設計値からずれて、むらを引き起こす。傾き角は加熱温度だけではなく、ラビング条件にも依存する。一般に、ラビング強度が高いと傾き角は低下する傾向にあるが、その変動の度合いは使用する配向膜材料やラビングによる配向膜表面の汚染等にも依存する。傾き角は以下の理由により、高すぎても低すぎても良くない。例えば、傾き角が設計値よりも低くなった場合、特に画素端部の配線等の存在により段差が生じている部分において配向不良ドメインが生じ、著しくコントラスト比が低下してしまう。逆に、傾き角が設計値よりも高くなった場合、傾き角の均一性を保つことが困難になり、輝度むらが発生する。現状では量産的には4度程度の均一な傾き角を得るために、使用する材料を厳しく吟味し、その上で加熱プロセス，ラビングプロセス等厳しく制御されているが、表示むらは皆無になってはいない。

【０００６】（２）液晶の高純度の維持

縦電界方式と薄膜トランジスタのような微細なアクティブマトリクス素子を組み合わせる場合に考慮すべき他の物性は、液晶組成物材料の純度であり、その値は10^{13} Ω・cm以上と極めて高い値を維持することが不可欠である。これは、画素に電荷を供給し、情報を表示する際にため込んだ電荷を少なくとも次の情報信号が供給されるまで保持しなくてはならないという駆動原理からの要請による。一般に、この期間（１フレーム期間と称する）内にどの程度電荷が保持されるかという度合いを、１フレーム期間内の輝度の保たれる割合で定義し電圧保持率として表している。この電圧保持率は液晶の純度に極めて敏感であり、そのため、液晶組成物材料を構成する化合物もフッ素系の化合物群の中のほんの一部に限定されているのが現状である。また、配向膜材料に対する制約も大きい。すなわち、もし液晶に直接接触する配向膜材料そのものの純度が低い場合、セル形成後に徐々に液晶組成物材料が汚染され、電圧保持率が著しく低下し、かつその低下の度合いが場所によって分布し、均一な表示が得られなくなる。現状では液晶汚染に対し使用設備のクリーン化等により最大限の注意を払っているが、電圧保持率は１００％ではなく、表示むらは皆無にはなっていない。

【０００７】（３）残像現象

メカニズムは不明であるが、固定した静止画像を表示した後、別の画像に切り替えても前の画像が残存するいわゆる残像現象も配向膜と液晶材料の双方に強く依存している。メカニズムが不明であるため、材料設計は困難を極めている。

【０００８】以上のように、界面の精密な制御（所定の傾き角の維持）、液晶の高純度の維持、残像の抑制等多数の要求仕様を同時に満足させることは至難の技で、工程を長くし、かつ極めて狭い範囲のプロセス条件下で無理をして製造しているのが現状である。例えば、配向膜の加熱工程では２００℃以上の極めて高い温度で処理している。このように、厳しいプロセス条件を設定せざるを得ないことから、液晶セルを構成する他の材料の選択範囲も狭くなり、このことが製造条件の裕度をさらに狭め、ますます表示むらを引き起こしやすくしている。

【０００９】本発明はこれらの課題を解決する手段を提供するもので、その目的とするところは、アクティブ素子と横電界方式とより低い温度のプロセスで処理出来る溶剤に可溶なポリマの配向膜とを組み合わせることで、表示むらのない高画質のアクティブマトリクス型液晶表示装置の製造方法を提供することにある。

【００１０】

【課題を解決するための手段】前記課題を解決し、上記目的を達成するために本発明では以下の手段を用いる。

【００１１】〔手段１〕以下の工程からなることを特徴とする液晶表示装置の製造方法。

【００１２】（１）セルを構成する一対の基板の一方の基板上に走査電極，共通電極，走査電極と交差する信号電極，アクティブ素子，画素電極を有し、該画素電極と該共通電極が主として液晶に対して基板面に平行な電界を印加するように配置されたマトリクス素子を形成する工程。

【００１３】（２）該基板上に、溶剤に可溶なポリマの溶液を塗布する工程。

【００１４】（３）該ポリマの溶液中の溶剤を除去する工程。

【００１５】（４）該ポリマの表面に液晶分子配向能を付与する工程。

【００１６】（５）表面に液晶分子配向能を有する一対の基板をスペーサと基板周辺部に形成されたシール部とを介して、液晶分子配向能を有する表面どうしを相対向させてセルを組み立てる工程。

【００１７】（６）該セルに液晶組成物を注入，封止し液晶セルを形成する工程。

【００１８】（７）該液晶セルに駆動回路，偏光手段を接続しモジュール化する工程。

【００１９】手段１は、アクティブ素子と横電界方式とより低い温度のプロセスで処理出来る溶剤に可溶なポリマの配向膜とを組み合わせることで、表示むらのないより高画質のアクティブマトリクス型液晶表示装置を得る方法を提供する。

【００２０】〔手段２〕前記アクティブ素子が薄膜トランジスタ素子であることを特徴とする手段１に記載の液晶表示装置の製造方法。

【0021】〔手段3〕前記溶剤に可溶なポリマがポリイミドであることを特徴とする手段1に記載の液晶表示装置の製造方法。

【0022】〔手段4〕前記溶剤に可溶なポリマがポリアミドであることを特徴とする手段1に記載の液晶表示装置の製造方法。

【0023】手段2から手段4は、アクティブ素子及び溶剤に可溶なポリマとしてより望ましい手段を提供している。薄膜トランジスタ素子がアクティブ素子として優れている。また、ポリイミド、及びポリアミドは液晶配向能の高い緻密な高分子配向膜の中でも特に優れている。

【0024】〔手段5〕前記一対の基板のうち前記マトリクス素子を有する基板に対向する基板が(2)から(4)の工程を経ることを特徴とする手段1に記載の液晶表示装置の製造方法。

【0025】〔手段6〕前記マトリクス素子を有する基板に対向する基板上にカラーフィルタを形成し、液晶セルとして複数の発色能を付与したことを特徴とする手段5に記載の液晶表示装置の製造方法。

【0026】〔手段7〕前記一対の基板のうち前記マトリクス素子を有する基板が（2）から（4）の工程を経ることを特徴とする手段1に記載の液晶表示装置の製造方法。

【0027】〔手段8〕前記マトリクス素子を有する基板上にカラーフィルタを形成し、液晶セルとして複数の発色能を付与したことを特徴とする手段7に記載の液晶表示装置の製造方法。

【0028】手段5から手段8は一方の基板に限定して溶剤に可溶なポリマを形成する手段を提供する。

【0029】〔手段9〕以下の工程からなることを特徴とする手段6あるいは8に記載の液晶表示装置の製造方法。

【0030】（1）複数の発色層を有する膜を形成する工程。

【0031】（2）複数の色からなる光パターンを照射しカラーフィルタを形成する工程。

〔手段10〕光照射工程が1回であることを特徴とする手段9に記載の液晶表示装置の製造方法。

【0032】〔手段11〕一対の高分子保護膜で挟まれた前記発色層からなるフィルムに光パターンを照射しカラーフィルタを形成した後、前記一方の基板上に該フィルムを貼付けすることを特徴とする手段9あるいは10に記載の液晶表示装置の製造方法。

【0033】手段9から手段11は、従来はその後の配向膜形成工程で高温加熱プロセスが存在する為に使用出来なかった、より色の鮮やかな写真法によるカラーフィルタの製造方法を提供するものである。

【0034】〔手段12〕前記液晶セル組立て時に複数のカラーフィルタの境界部を遮光する遮光層を前記一対の基板の少なくとも一方の基板上に形成することを特徴とする手段6あるいは8に記載の液晶表示装置の製造方法。

【0035】〔手段13〕前記マトリクス素子を有する基板上に前記遮光層を形成し、前記マトリクス素子に対向する基板上に前記複数のカラーフィルタを形成することを特徴とする手段12に記載の液晶表示装置の製造方法。

【0036】〔手段14〕前記マトリクス素子を有する基板上に前記遮光層と前記複数のカラーフィルタを形成することを特徴とする手段12に記載の液晶表示装置の製造方法。

【0037】手段12から手段14はより遮光性の高い遮光層を得、より高画質のアクティブマトリクス型液晶表示装置を得る方法を提供する。

【0038】

【作用】

（1）横電界方式の動作原理

先ず初めに、本発明の必須構成である横電界方式の動作原理を説明する。図2は電界方向9に対する界面近傍での液晶分子長軸（光学軸）方向10のなす角ϕ_{LC}，偏光板の偏光透過軸11のなす角ϕ_Pの定義を示す。偏光板及び液晶界面はそれぞれ上下に一対あるので必要に応じてϕ_{P1}，ϕ_{P2}，ϕ_{LC1}，ϕ_{LC2}と表記する。尚、図2は後述する図1の正面図に対応する。

【0039】図1（a），（b）は本発明の液晶パネル内での液晶の動作を示す側断面を、図1（c），（d）はその正面図を表す。図1には薄膜トランジスタ素子部は省略され配線電極構造の1部が示されている。また、本発明の表示装置は複数の画素で構成されるが、ここでは一画素の中の部分のみを示した。電圧無印加時のセル側断面を図1（a）に、その時の正面図を図1（c）に示す。透明な一対の基板の内側に線状の電極1，4が形成され、その上に保護絶縁膜5が塗布及び配向処理されている。この図では保護絶縁膜5は保護膜と配向制御膜が一体化して描かれているが、ひとつの材料で兼用しても、2つの材料を積層しても良い。間には液晶組成物が挟持されている。棒状の液晶分子6は、電界無印加時には電極1，4の長手方向（図1（c）正面図）に対して若干の角度、即ち45度≦｜ϕ_{LC}｜＜90度、をもつように配向されている。図1，図2では界面上の液晶分子長軸配向方向（ラビング方向）10を矢印で示した。上下界面上での液晶分子配向方向は、望ましい1例として平行、即ち$\phi_{LC1}=\phi_{LC2}$（$=\phi_{LC}$）となっている。液晶組成物の誘電異方性は正を想定している。

【0040】ここで、画素電極4と共通電極1のそれぞれに異なる電位を与えそれらの間に電位差を与えて液晶組成物層に電界方向9を印加すると、液晶組成物が持つ誘電異方性と電界との相互作用により図1（b），（d）に示したように液晶分子が反応して電界方向にその向き

を変える。この時液晶組成物層の屈折率異方性と偏光板との相互作用により明るさが変わる。

【0041】（2）配向膜材料および液晶材料の選択の自由度

つぎに、本発明の必須構成である横電界方式を採用することによって、配向膜材料および液晶材料の選択の自由度が増大する作用について説明する。発明が解決しようとする課題のところで述べたように、配向膜材料および液晶材料を選択する際には（1）界面の精密な制御、（2）液晶の高純度の維持、（3）残像現象の抑制の3点を考慮する必要がある。以下、これらの3点について縦電界方式を横電界方式に変換することによる効果について、順次説明する。

【0042】縦電界方式においては、液晶分子が低電界時にほぼ基板面に平行であったものを、基板面に垂直な方向の電界（縦電界）と液晶分子との誘電的相互作用により液晶分子を立たせることで光学的なスイッチングを行っている。この時、もし傾き角が完全にゼロであると傾く方向としては2種類存在することになり、その2種類のドメインの境界が配向不良領域（リバースチルトドメインと称する）となり、画質を著しく低下させる。現実の素子においては、画素の端部近傍には配線電極や薄膜トランジスタ等段差構造が多数あるために4度程度のある程度大きな傾き角がないと、このリバースチルトドメインを抑制することができない。縦電界方式における傾き角の必要性はあらかじめ電界印加時の液晶分子の傾く方向を一つに定めておく必要があることから生じている。換言すると、電界方向と初期の液晶分子配向方向とのなす角を90度より十分に小さくしなくてはならない。この角度は、経験的には最低でも88．5度以下、望ましくは86度以下である。即ち傾き角に換算すると、最低でも1．5度以上、望ましくは4度以上となる。一方、横電界の場合においても、同様に『配向不良領域を防ぐためには、電界方向と初期の液晶分子配向方向とのなす角を90度より十分に小さくすれば良い』というルールが適用できる。よって、電界方向が縦から横へ変わったために、縦電界方式における傾き角に対応する角度は基板面内の液晶分子の方位方向であり、縦電界方式で必須であった界面と液晶分子とのなす角は問題ではなく完全にゼロでも構わなくなる。傾き角を支配しているのは配向膜と液晶分子との分子レベルでの相互作用であったのに対し、基板面内の液晶分子の方位方向を決めるのはラビング方向という設計段階で自由に設定できるパラメータである。配向膜と液晶分子との分子レベルでの相互作用と一口に述べたが、現象は複雑で、材料の1次構造のみならず分子コメフォメーション等の2次構造も関与しており、プロセス条件依存性を避けることはできない。従って、横電界方式を採用することにより傾き角の制約から完全に開放され、この1点のみによっても材料、プロセスの選択の自由度が著しく向上する。本発明ではすでに重合した高分子配向膜を溶剤に溶かして塗布するプロセスを用いており、基板上で重合反応させる必要がなく高分子量で緻密な膜質がプロセス変動によらず得られる。また、ドメインおよび表示むらの抑制効果は光の利用効率の向上にも寄与する。即ち、薄膜トランジスタのような段差構造のある部分の近傍で生じていた配向不良部分を従来はブラックマトリクスで遮光していたものが、本方式では遮光部の面積を小さくすることが出来る。その結果、開口率およびそれに伴い光の利用効率が向上し、より明るいディスプレイが得られるという効果も得られる。

【0043】次に第2の要請である、液晶の高純度の維持に対しても横電界方式は極めて自由度が大きくなる作用について説明する。薄膜トランジスタ型液晶表示装置のようなアクティブマトリクス型液晶表示装置において、液晶には走査選択時間内のみに画像情報信号が印加され、他のラインが選択される非選択時間内には画素部は回路的にはオープン状態となる。この間、信号配線電極より供給された電荷は、つぎにそのラインが選択されるまでの期間（1フレーム期間）保持されなくてはならない。この電荷の保持期間である時定数は、主として画素部全体の静電容量と電気抵抗の積で定まる。しかしながら、縦電界の場合、液晶が実現しうる電気抵抗の最大値をもっても、液晶自体が保有する静電容量だけでは不十分であり、画素ごとに配線等を引き回して容量部を付加しているのが現状である。これに対し、縦電界の場合は電極が線状になり、抵抗値を決める電界方向に垂直な方向の断面積が著しく小さくなる。したがって、液晶組成物の比抵抗が同一であっても液晶画素部の抵抗値は著しく低減できる。一方容量の方は、逆に抵抗値に逆比例して小さくなりこの点では不利になる。しかしながら、抵抗値の増大が著しく（100倍以上）、そのため従来形成していた付加容量と組み合わせることで、十分に電圧を保持できる。むしろ、従来と同程度の付加容量素子があれば液晶の抵抗値が10分の1ないし100分の1に下がってもまったく問題無い。このように、液晶の耐汚染性が著しく向上したことにより、液晶そのもののみならず、液晶に接する配向膜，シール剤，封止剤といった周辺部剤の選択の自由度およびそれらを形成するプロセス裕度が著しく増大する。本発明の溶剤に可溶なポリマを溶液状で塗布する工程では、従来のような高温加熱が不要で表面状態をより均一にしやすい。また、残留溶剤がしみだす等により多少液晶を汚染しても電圧保持率を低下させず、この点でも表示むらになりにくい。

【0044】第3の要請である残像現象の抑制にも本発明は顕著な効果がある。残像現象も界面現象が視認されたものである。一般に界面現象は、界面に垂直な方向の性質として表れる。横電界方式の場合、電界の主成分は界面に平行であり、このような一切の界面現象は表れにくい。実際、後に実施例にて述べるように、いずれの実

施例においても残像現象は皆無であった。

【0045】以上のような3点にも及ぶ効果により、界面現象や液晶内の微量の汚染が関与した種々の表示むらが抑制され、均一な高画質の表示装置が実現できる。加えて今までにはまったく不可能であった、新しいプロセスが可能となる。即ち、配向膜，シール剤，封止剤といった材料の選択の自由度が増大したことにより、例えば加熱温度の大幅低減，加熱プロセス時間の短縮をもたらす。またさらに、耐熱性，汚染防止能等の制約から使えなかった周辺部剤であるカラーフィルタ，遮光用材料等が使えるようになる。その結果、より表示むらを抑制し画質を著しく引き上げることのできる構成材料が選択できるようになる。本発明はこれらの横電界方式の特徴を活用して、配向膜材料としてより裕度の高い低温プロセスが適用出来る溶剤に可溶なポリマを採用し、配向膜の膜質を安定化させ、表示むらのない液晶表示装置が得る方法を提供するものである。加えて、加熱温度の大幅低減，加熱プロセス時間の短縮といった低コストプロセスの適用は、生産電力の著しい抑制にもつながり、製造コストの低減，エネルギー資源の節約にも寄与する。

【0046】

【実施例】本発明を実施例により具体的に説明する。

【0047】〔実施例1〕基板としては厚みが1.1mmで表面を研磨した透明なガラス基板を2枚用いる。まずこれらの基板のうち一方の基板の上に薄膜トランジスタを下記の手順で形成した。なお、薄膜トランジスタおよび配線電極からなるマトリクス素子は横電界が印加出来るものであれば何でも良くその製法は本発明の骨子には関係しないので、記述は簡単化する。また、マトリクス素子の製法に関するここでの記述は1例であって、これに限定されるものではない。以下1画素の構造を示す図3のC−C′間の断面図を模式的に表した図7，図8，図9を用いて本実施例を説明する。

【0048】透明なガラスの基板7の一方の上に、スパッタ法によりクロム膜を形成し、次に、ホトリソグラフィ法により走査電極12と共通電極1をパターン化した（図7（a））。その後、その上にCVD(Chemical Vapor Deposition) 法により窒化シリコン（SiN）からなるゲート絶縁膜を形成し（図7（b））、更にその上に同じくCVD法により、表面層がn型非晶質シリコン（a−Si）膜であるa−Si13を作製した（図7（c））。a−Si13の一部を覆い薄膜トランジスタを形成するようにクロムからなる信号電極3及び画素電極4を、スパッタ法，ホトリソグラフィ法により形成した（図7（d））。その上に、SiNからなる絶縁保護膜を形成した（図8（e））。その後、その上に遮光層22と顔料のカラーフィルタ23cを形成し、更にその上に樹脂の平坦化膜23bをスピンコートした（図8（f））。遮光層としてはキャボット社製カーボン微粒子(MONARCH800, 粒径16nm）を1重量%混合したエポキシ樹脂を用いた。カラーフィルタの発色用顔料としては赤，緑，青の3原色に対してそれぞれフジハント社製CR−6101，CG−5101，CB−6101を用いた。スピンコートにより塗布し、85℃でプリベークした後、露光，現像を行い、最後に200℃でポストベークして膜状のカラーフィルタを形成した。本実施例では、発色層として顔料を用いたが、本発明によればその後の配向膜形成プロセスで高温に加熱する必要がないため、耐熱性の低いより色の鮮やかな染料タイプの発色剤を使用しても良い。また、遮光層用材料としても本実施例ではカーボンブラック微粒子のような液晶の比抵抗を低下させる汚染源となる可能性のある材料を用いたが、横電界方式そのものが汚染に強いため問題ない。むしろ、カーボンブラック微粒子は遮光率に極めて優れるため、より高い画質が実現出来る。もちろん、カーボンブラック微粒子以外の顔料や染料等の他の絶縁製遮光剤を用いてもなんら問題はない。またその上の平坦化用の樹脂としてはエポキシ樹脂を用いたが、こちらもこの材料に限定されるものではない。次に、イミド化率が100%である溶剤可溶型のポリイミドであるAL−1051（日本合成ゴム社製）のポリマ溶液24aをスピンコート法により塗布した（図8（g））。本実施例では、溶剤としては極性溶媒であるジメチルホルムアミドと非極性溶媒であるブチルセルソルブを重量比で8：2で混合したものを用いたが、極性溶媒であればジメチルホルムアミド以外でもN−メチル−2−ピロリドンやジメチルアセトアミドでも、また非極性溶媒であればブチルセルソルブアセテートでも良い。また、本実施例では塗布方法としてスピンコート法を採用したが、凸版印刷，オフセット印刷，スクリーン印刷等の各種の印刷法，ロールコーティング法，ディップ法等均一な膜厚に塗布出来る方法であればこれに限るものではない。その後、この溶液を160℃まで加熱し、30分放置し溶剤を除去した。このようにして緻密なポリイミド配向膜であるポリマ24bを得た（図8（h））。次に、この表面をラビング処理し、配向膜表面に液晶配向能を付与した（図9（i））。本実施例では配向能を付与する方法として、ラビング法を採用したが、それ以外の例えば微細な溝を形成する方法等の他の方法も利用出来る。次に、同様の材料とプロセスで配向膜表面に液晶配向能を付与した対向側の基板と、それぞれの液晶分子配向能を有する表面24dどうしを相対向させて、ポリマビーズからなるスペーサと周辺部のシール剤とを介在させてセルを組み立てた（図9（j））。このセルに液晶分子6を真空で注入し、紫外線硬化型樹脂からなる封止剤28で封止した。その後、このセルに駆動回路、偏光板，バックライト等を接続してモジュール化し液晶表示装置を得た。

【0049】次にこのようなプロセスで得た液晶表示装置の構成について、より詳細に説明する。

【0050】上下界面上のラビング方向は互いにほぼ平

行で、かつ印加電界方向とのなす角度を８８度（$\phi_{LC1} = \phi_{LC2} = 88°$）とした。これらの基板間に挟まれたネマチック液晶組成物の誘電異方性$\Delta\varepsilon$は正でその値が４．５であり、屈折率異方性Δｎは0．072（５８９ｎｍ，２０℃）である。またこの液晶組成物は当初その抵抗値が10^{11} Ω・cm以上あったが、その後汚染し、3．6×10^{12} Ω・cm まで低下した。本実施例ではこの汚染したものを用いた。ギャップｄは球形のポリマビーズを基板間に分散して挟持し、液晶封入状態で３．９μｍとした。よってΔｎ・ｄは0．２８１μｍ である。また、同一の配向膜材料を同一プロセスでガラス基板上に形成し、結晶回転法で液晶分子長軸の傾き角を測定したところ、僅かに１．２ 度であった。２枚の偏光板〔日東電工社製Ｇ１２２０ＤＵ〕でパネルを挟み、一方の偏光板の偏光透過軸をラビング方向より若干小さな角度、即ち$\phi_{P1} = 80°$（即ち、$|\phi_{LC1} - \phi_{P1}| = 8°$）に設定し、他方をそれに直交、即ち$\phi_{P2} = -12°$とした。これにより、画素に印加される電圧$V_{LC}$をゼロから徐々に増大させるにしたがい明るさが減少し最小値をとる特性（図４）を得た。本実施例では低電圧（V_{OFF}）で暗状態、高電圧（V_{ON}）で明状態をとるノーマリクローズ特性を採用した。V_{OFF}は6．9Ｖ、V_{ON}は9．1Ｖである。

【００５１】薄膜トランジスタ及び各種電極の構造を図３に示し、詳細に説明する。図３（ａ）は基板面に垂直な方向から見た正面図、図３（ｂ），（ｃ）は側断面図を表す。薄膜トランジスタ素子１４は画素電極（ソース電極）４，信号電極（ドレイン電極）３，走査電極（ゲート電極）１２、及びアモルファスシリコン１３から構成される。共通電極１と走査電極１２、及び信号電極３と画素電極４とはそれぞれ同一の金属層をパターン化して構成した。容量素子１６は、２本の共通電極１の間を結合する領域（図３において点線で示した）において画素電極４と共通電極１でゲート絶縁膜２を挟む構造として形成した。画素電極４は正面図（図３（ａ））において、２本の共通電極１の間に配置されている。１画素ピッチ１５は横方向（すなわち信号電極間）は６９μｍ、縦方向（すなわち走査電極間）は２０７μｍである。電極幅は、複数画素間にまたがる配線電極である走査電極，信号電極，共通電極配線部（走査電極に平行（図３で横方向）に延びた部分）を広めにし、線欠陥を回避した。幅はそれぞれ１０μｍである。一方、開口率向上のために１画素単位で独立に形成した画素電極、及び共通電極の信号配線電極の長手方向に伸びた部分の幅は若干狭くし、それぞれ５μｍ，８μｍとした。これらの電極の幅を狭くしたことで異物等の混入により断線する可能性が高まるが、この場合１画素の部分的欠落ですみ線欠陥には至らない。加えて、更にできるだけ高い開口率を実現するために絶縁膜を介して共通電極と信号電極を若干（１μｍ）重ねた。これにより、信号配線に平行な方向のブラックマトリクスは不要になる。そこで図３（ｃ）に示されているように、走査電極方向のみ遮光するブラックマトリクス構造とした。このようにして、共通電極と画素電極とのギャップが２０μｍ、開口部の長手方向の長さ１５７μｍとなり、４４．０％ の高開口率が得られた。画素数は３２０本の信号電極と１６０本の走査電極とにより３２０×１６０個とした。複数画素から構成されるパネルの部分を図５，図６に示す。図５ではブラックマトリクスを省略し、図６ではブラックマトリクスで遮光した状態を示した。

【００５２】次に、回路構成及び駆動波形について説明する。各走査電極１２および各信号電極３にはそれぞれ信号電極駆動回路１８および走査電極駆動回路１９を接続した。また、共通電極１にも共通電極駆動回路２０を接続した（図１３）。信号電極３には情報を有する信号波形が印加され、走査電極１２には走査波形が信号波形と同期をとって印加される。信号電極３から薄膜トランジスタ素子１４を介して画素電極４に情報信号が伝達され、共通電極１との間で液晶部分に電圧が印加される。図１４には駆動電圧波形の具体例を示す。なお、本実施例の場合の振幅は、

$V_{D-CENTER} = 14.0$，$V_{GH} = 28.0$，$V_{GL} = 0$，$V_{SH} = 15.1$，$V_{SL} = 12.9$，$V_{CH} = 20.4$，$V_{CL} = 4.39$

に設定し、その結果、ゲート電極とソース電極の間の寄生容量による飛込み電圧ΔV_{GS}(+)，ΔV_{GS}(−)，画素電極にかかる電圧V_S，液晶にかかる電圧V_{LC}は下表のようになった。なお、電圧の単位は以後すべてボルトとする

【００５３】
【表１】

表 1

各種電圧値

表示状態	$\Delta V_{GS}(+)$	$\Delta V_{GS}(-)$	V_{SH}	V_{SL}	V_{LCH}	V_{LCL}	V_{rms}
明	+1.76	−1.64	+11.14	−13.46	+9.24	−9.07	9.16
暗	+1.47	−1.57	+13.63	−11.33	+6.75	−6.94	6.85

【0054】図4に示すV_{ON}，V_{OFF} はそれぞれ9.16ボルト，6.85ボルトとなった。本実施例では、配向膜の形成プロセス温度を溶剤を除去するために十分な160℃という従来に比べて非常に低い温度とした。また傾き角は1.2 度という従来の縦電界方式では配向不良が生じてしまうほど、低い値になったが、リバースチルトドメインのような配向不良はまったく生じなかった。また、傾き角が低くなった効果として、配向の不均一性がなくなり、表示の均一性も高まった。表示性能を輝度計で測定したところ、十分に高いコントラスト比８０が得られた。また、液晶の汚染等に伴うような表示むらも一切見られず、均一性の高い表示が得られた。さらに、固定パターンを一時間表示した後、別のパターンに切り替えたところ残像（焼き付き）現象はまったく視認されず、瞬時に新しいパターンに切り替わった。

【0055】〔実施例2〕本実施例では実施例1のポリイミド配向膜を溶剤可溶型のポリアミドＨＴＸ－６７００（日立化成製）に変えた。実施例1と同様に、溶液状態でポリアミドを塗布した後、この溶液を１５０℃まで加熱し、３０分放置し溶剤を除去し、緻密なポリアミド配向膜を得た。傾き角は、1.0 度であった。他の構成

は実施例１と同じである。モジュール化して特性を評価したところ、十分に高いコントラスト比１００が得られ、配向の不均一性やリバースチルトドメインのような配向不良、液晶の汚染等に伴う表示むらも一切見られず、均一性の高い表示が得られた。また、固定パターンを一時間表示した後、別のパターンに切り替えたところ残像（焼き付き）現象はまったく視認されず、瞬時に新しいパターンに切り替わった。

【0056】〔比較例1〕従来型の縦電界方式用薄膜トランジスタマトリクス基板上に実施例２と同様の方法で配向膜を形成した。カラーフィルタは対向基板上に形成された透明導電膜の下に形成した。表示方式はツイステッドネマチック方式とした。また、液晶材料としては汚染されておらず抵抗値が10^{14} Ω・cmあるものを用いた。これらの点以外は実施例２と同じようにした。

【0057】その結果、傾き角不足の為の配向不良ドメインが画素端部に発生し光散乱現象が起きコントラスト比が２５：１まで低下した。また、汚染した液晶を用いた時に現れる表示むらも発生した。

【0058】〔実施例3〕本実施例では、カラーフィルタを対向基板側に形成した。本実施例の液晶表示装置の断面模式図を図１０に示す。対向側の基板７の上に、複数の色を有するカラーフィルタ２３ｃを積層し、複数の色の境界がマトリクス基板上の遮光層２２の真上に配置されている。遮光部の幅は５０μｍと一般的な液晶パネル組立て装置の基板間のアライメント精度の３～１０μｍに比べて大変に広いため、極めて簡便に組み立てられる。また、本実施例のカラーフィルタは、富士写真フィルム社製のポジ型フィルムFUJICHROME, PROVIA, 100DAY LIGHT, RDPII135 に一回の光照射で複数の色のパターンを形成して作製した。フィルムはあらかじめ２枚の保護フィルムの間に複数の発色層を有し、そのため液晶表示装置として必要な色のパターンに対応したフォトマスクを通して光を照射すれば、１回の光照射でカラーフィルタが得られる。この、カラーフィルタを対向基板の上にエポキシ系接着剤により加圧しながら室温で接着した後、実施例と同様の配向膜形成プロセスを経てセル化した。この際、溶剤は８０℃で、１０mmＨｇの減圧状態で５時間かけて除去した。その他の条件は、実施例２と同様である。

【0059】モジュール化して特性を評価したところ、十分に高いコントラスト比１００が得られ、配向の不均一性やリバースチルトドメインのような配向不良、液晶の汚染等に伴う表示むらも一切見られず、均一性の高い表示が得られた。また、固定パターンを一時間表示した後、別のパターンに切り替えたところ残像(焼き付き)現象はまったく視認されず、瞬時に新しいパターンに切り替わった。加えて、このようなポジ型フィルムから作製したカラーフィルタの色調は非常に鮮やかで、これを用いた本発明の液晶表示装置の色も鮮やかになった。

【0060】なお、本実施例では発色層を保護フィルムの間にサンドイッチしたものを用い、カラーフィルタパターンを形成した後にガラス基板と接着したが、初めからガラス基板上に発色層を形成しても構わない。また、光露光は1回が製造コストの点では望ましいが、複数回行っても構わない。

【0061】〔実施例4〕本実施例では、Kodak 社製のポジ型フィルムEKTACHROME DYNA 100を用いて実施例3と同様のプロセスでカラーフィルタを作製した。また、カラーフィルタのパターンの中に遮光層を備え、アクティブ素子内には遮光層を形成しなかった。図12は本実施例のカラーフィルタ内の遮光層の配列を示す。図12（a）は側断面を、図12（b）正面から見たときのパターンを表す。

【0062】同様に、モジュール化して特性を評価したところ、十分に高いコントラスト比90が得られ、配向の不均一性やリバースチルトドメインのような配向不良，液晶の汚染等に伴う表示むらも一切見られず、均一性の高い表示が得られた。また、固定パターンを一時間表示した後、別のパターンに切り替えたところ残像（焼き付き）現象もまったく視認されず、瞬時に新しいパターンに切り替わった。実施例3と同じく、このようなポジ型フィルムから作製したカラーフィルタの色調は非常に鮮やかで、これを用いた本実施例の液晶表示装置の色も鮮やかになった。

【0063】以上実施例1から4により、薄膜トランジスタ素子のようなアクティブ素子において横電界方式と溶剤に可溶なポリマを配向膜として採用することにより、液晶の汚染に対する裕度や、配向膜ワニスを塗布した後の加熱温度が低くて良い等配向プロセスに対する裕度が増大し、表示むらのない高画質の液晶表示装置が得られた。

【0064】

【発明の効果】本発明によれば、薄膜トランジスタ素子のようなアクティブマトリクス素子において横電界方式と塗布後の加熱温度が低くて良い溶剤に可溶なポリマを組み合わせることにより、液晶の汚染や、配向プロセスに対する裕度が増大し、表示むらのない高画質の液晶表示装置が得られる。

【図面の簡単な説明】

【図1】本発明の液晶表示装置における液晶の動作を示す図。

【図2】電界方向に対する、界面上の分子長軸配向方向（ラビング方向）ϕ_{LC}，偏光板偏光透過軸方向ϕ_Pのなす角を示す図。

【図3】本発明の液晶表示装置の薄膜トランジスタ，電極，配線の構造を示す図。［（a）正面図、（b），（c）側断面図。］

【図4】本発明の液晶表示装置の電気光学特性を示す図。

【図5】本発明の液晶表示装置の複数画素の配置を示す図。

【図6】本発明の液晶表示装置の複数画素の配置を示す図。

【図7】本発明の液晶表示装置の製造プロセスを示す図。

【図8】本発明の液晶表示装置の製造プロセスを示す図。

【図9】本発明の液晶表示装置の製造プロセスを示す図。

【図10】カラーフィルタを搭載した本発明の液晶表示装置の側断面図。

【図11】本発明の液晶表示装置のカラーフィルタの製法を示す図。

【図12】本発明の液晶表示装置のカラーフィルタの別の実施例。

【図13】本発明の液晶表示装置の回路を示す図。

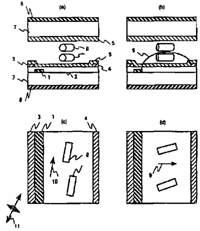
【図14】本発明の液晶表示装置の別の駆動波形を示す図。

【符号の説明】

1…共通電極（コモン電極）、2…ゲート絶縁膜、3…信号電極（ドレイン電極）、4…画素電極（ソース電極）、5…保護絶縁膜、6…液晶組成物層中の液晶分子、7…基板、8…偏光板、9…電界方向、10…界面上の分子長軸配向方向（ラビング方向）、11…偏光板偏光透過軸方向、12…走査電極（ゲート電極）、13…アモルファスシリコン、14…薄膜トランジスタ素子、15…1画素ピッチ、16…付加容量素子部、17…コントロール回路、18…信号電極駆動回路、19…走査電極駆動回路、20…共通電極駆動回路、21…表示領域、22…遮光層、23a…発色層、23b…平坦化膜、23c…カラーフィルタ、23d…高分子保護膜、24a…ポリマ溶液、24b…ポリマ、24c…ラビングローラ、24d…配向膜、25…フォトマスク、26…光、27…シール剤、28…封止剤。

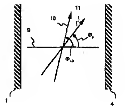
【図1】

図 1



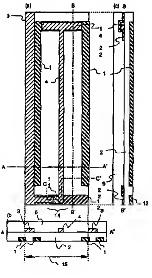
【図2】

図 2



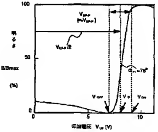
【図3】

図 3



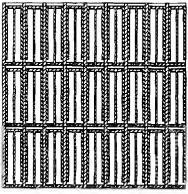
【図4】

図 4



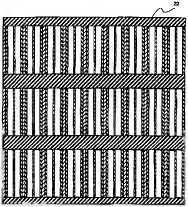
【図5】

図 5



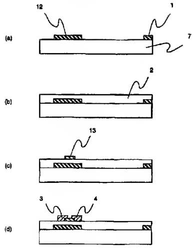
【図6】

図 6



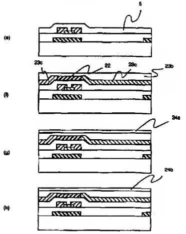
【図7】

図 7



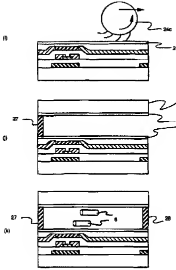
【図8】

図 8



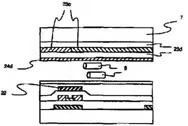
【図9】

図 9



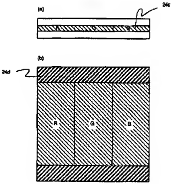
【図10】

図 10



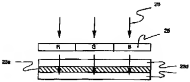
【図12】

図 12



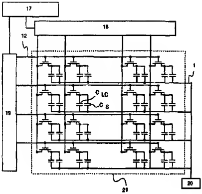
【図11】

図 11



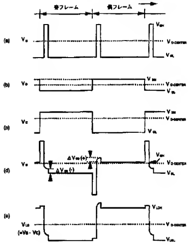
【図13】

図 13



【図14】

図 14



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